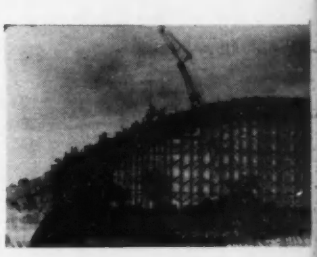
CONCRETE CONSTRUCTION P O BOX 444 ELMHURST ILLINOIS TERRACE 4 5110

AUGUST 1960

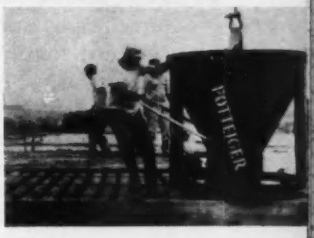
COMING NEXT MONTH



Sectional Steel Shoring. Contractors who are concerned about the high cost of shoring concrete work will be interested in this article on prefabricated, easy-to-handle steel sections that cut down on time, labor, and materials.

Horizontal Shoring. In this same issue . . . another article on a shoring innovation: a horizontal method that is easily and quickly erected on the job and, again, saves the contractor time and man-hours, as well as cutting down on materials used.

Steam Curing on Job Site. A resourceful contractor has created a method by which pretensioned girders for bridges on a highway project were cast and steam cured on the job site.



Voided Concrete Decks. How the use of fibre void tubes on one school project made it possible for concrete to replace some 200 tons of structural steel.

Over 35,000 copies mailed. Edited for all who are concerned with quality, job placed concrete (including prestress, tilt-up, lift slab, and thin-shell)—its specification, production, handling, forming, reinforcing, placing, finishing, and curing: *Concrete Contractors, General Contractors, Engineers, Architects, Industrial Construction and Maintenance Men, Highway Engineers, Ready-Mixed and Prestressed Concrete Producers.*

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Here is Concrete Construction's second article[1] designed to provide its readers with some basic criteria to use in analyzing and preventing pavement defects

By F. N. Hveem[2]

Prevention of Pavement Faults

CONCRETE PAVEMENTS ARE OLDER than either automobiles or airplanes. In fact, there is a concrete pavement still in service in the United States built in 1892 on the streets of Bellefontaine, Ohio. This oldest surviving concrete pavement shows evidence of surface indentations or "pock marks" built in to prevent Old Dobbin from slipping. We also have a sample of a concrete pavement base constructed in the city of Sacramento, California, in 1889. Here, however, the danger of a slippery surface was avoided by the use of a stone block wearing surface resting on the concrete base. Concrete pavements have been improved during the last 70 years but we have not reached the point where all possibility of failure has been eliminated.

When the automobile came along, it was soon evident that even a Model "T" could tear up dirt and gravel roads to a far greater extent than horse drawn stage coaches or freight wagons, and the need for smooth, dustless pavements became paramount. Concrete pavements constructed on the rural highways between 1915 and 1920 were typically 4 inches in thickness usually resting directly on the native soil roadbed which generally had been given little or no compaction. Soon after being open to traffic, the number and weight of trucks on these pavements increased greatly. The soft earth foundations became saturated with water and extensive failures developed in many cases.

Most people, and engineers especially, are inclined to think that whenever a pavement or any other structure fails it must be because it is too weak and that the way to correct the situation is to make the next design stronger. Thus, concrete pavements have increased in thickness from the original 4 inches successively to 6 inches, 7 inches, 8 inches, 9 inches, and today even 10 inches is not uncommon on many state highways, and thicknesses up to 27 inches have been placed on some of the large military airfields. However, making concrete pavements thicker and stronger and reinforcing with steel has not solved all the problems. Anyone designing a concrete slab to rest directly on the ground must allow for the fact that there is a great deal of difference between the behavior of a relatively rigid monolithic slab and the underlying soil when both are subject to loads. This is even more true when the loads are suddenly applied over a local area and suddenly removed as happens under a heavy vehicle traveling over the surface. Except where solid rock is exposed, the surface of the earth is relatively resilient, and anyone who has compared walking or standing on a concrete floor all day to doing the same thing on a springy turf appreciates the difference. When a concrete pavement slab is subjected to a heavy wheel load it may bend or flex a small amount, but if this bending goes very far the slab will break. On the other hand, the natural earth, if not too wet, may sustain the same load although it will compress or deflect farther in the process. Therefore, it is easy to see that when a concrete pavement is subjected to load the slab may break before the underlying soil support has been compressed or "mobilized" sufficiently to carry the load. It is, therefore, essential that there be some transition zone between the pavement and the native soil. This zone may consist of one or more layers which are commonly called the base and subbase, respectively, and which should be more rigid and uncompressible than the underlying soils but somewhat

[1] The first one: *An Analysis of Pavement Defects*, Concrete Construction, December 1959, page 8.

[2] The author is Materials and Research Engineer for the California Division of Highways, Sacramento.

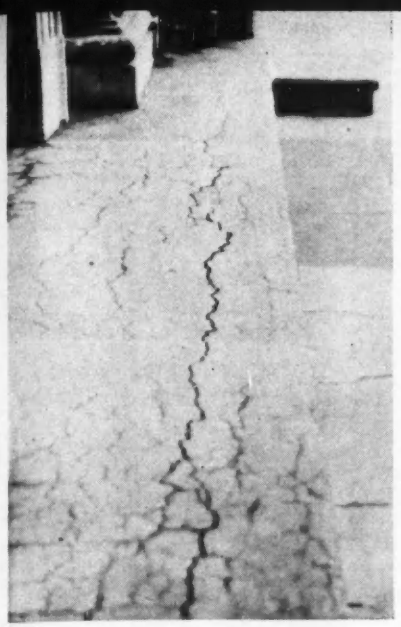


Figure 1

Two examples of cracking caused by interaction between alkalies in high alkali cement and certain types of aggregates containing opal or other reactive natural glassy constituents. Cracking and distress of this type may be completely prevented by avoiding the use of portland cement that is high in alkali. The California Division of Highways places a limit of 0.06 percent of alkalies in all portland cement used.

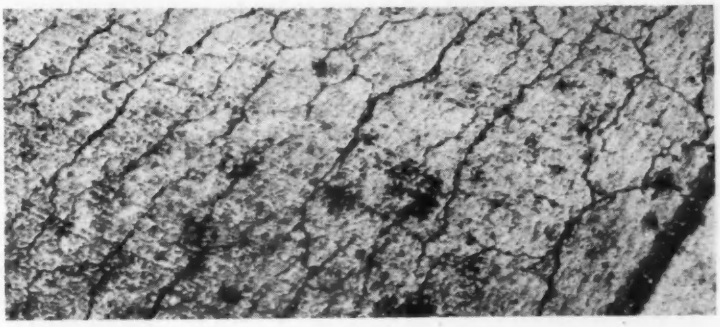


Figure 2

Figure 3

Longitudinal cracks entirely attributable to vertical movement, expansion or settlement of the underlying soil. Prevention—Either avoid the use of expansive soils or see that such soils have not been compacted in a state so dry that extreme swelling or expansion will develop when the water is finally taken up.

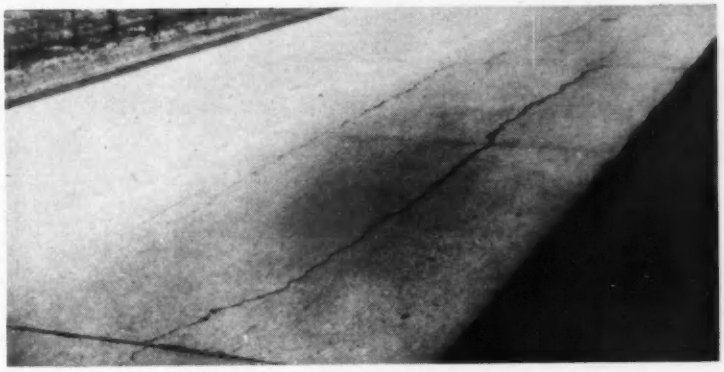
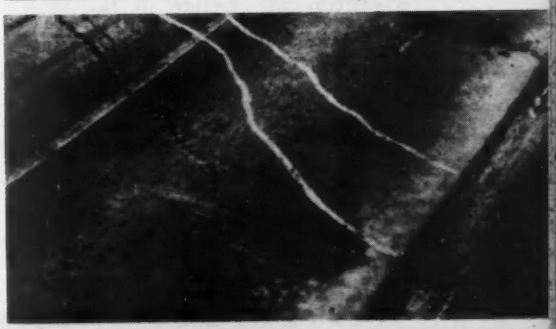


Figure 4

Figure 5 (right)

Figure 6 (lower right)



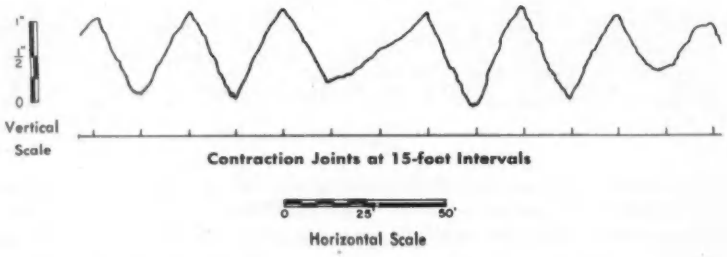
Cracks in the form of corner breaks usually attributed to curling of the slab which lifts the corners higher than any other portion. When subjected to load, the unsupported slab is bent downward and sooner or later may break as shown. This condition usually develops only where subgrade material has been pumped out by the continued rise and fall or pumping action of the slab ends under moving heavy wheel loads. Two expedients have been employed—one, to use load transfer devices such as dowels across the pavement joint. These dowels are troublesome to place in good alignment. They tend to bend or break under the bending action of the slabs at either side of the joint and in a relatively short time corrosion tends to freeze the dowels and render them inoperative. A better expedient is to treat the subgrade with cement or in some manner that will prevent erosion and maintain the support beneath the ends of the pavement slabs.

Figure 8 (right)

Figure 9 (lower right)

Figure 7

PROFILOGRAM OF PAVEMENT



An example of a concrete pavement constructed over an expansive soil which was thoroughly compacted at the so-called optimum moisture content. Water entered first through the joints in the pavement and the local swelling of the soil lifted the slabs at every second or third joint as shown by the exaggerated profile. If concrete pavements must be placed over expansive soils, the soil should be brought to the state of "no shrink, no swell" in order to prevent localized upthrust at the joints.

less so than the concrete slab above. In other words, avoid the abrupt change or discontinuity that ordinarily exists between a concrete pavement and the underlying soil.

Another characteristic of concrete pavement slabs which is not helpful or conducive to good performance is the susceptibility to volume change. Concrete expands and contracts both from the effects of changes in temperature and changes in moisture. It is only rarely that a concrete slab resting on the ground will be found to have a uniform temperature from top to bottom or to have a uniform distribution of moisture. Generally, the underside of the slab or the lower half of the slab is wet from being in contact with the damp ground while the upper surface is relatively dry from exposure to the air and sun. Both temperature and humidity of the atmosphere are subject to daily and seasonal variation and this means that there is almost a continuous change in the shape of concrete pavement slabs due to non-uniform moisture and temperature levels.

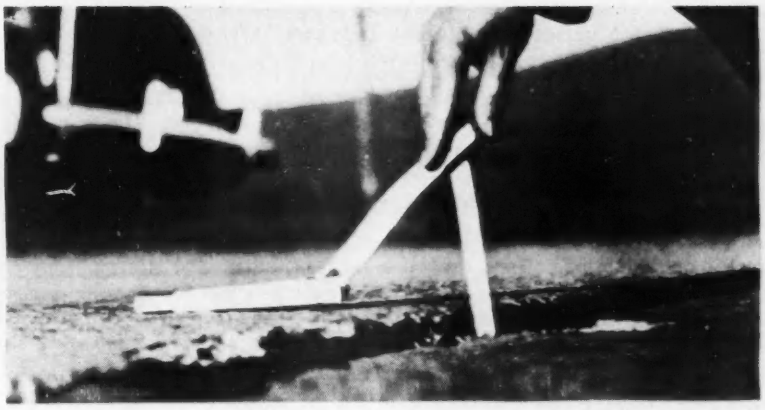
Some 20 or 30 years ago virtually all concrete pavements were constructed with expansion joints at regular intervals in order to allow for the expansion of the pavement with increase in temperature. In recent years, however, the use of expansion joints has been discontinued except where the pavements join bridges or at intersections with other pavements. Concrete pavements equipped with expansion joints have given a great deal of trouble as under heavy traffic there was a good deal of distress in the form of pumping, faulting of the pavement, et cetera. Today, virtually all concrete pavements are constructed with contraction joints in the form of weakened plane joints ranging from 15 to 50-foot intervals.

It is well known, of course, that portland cement must be tempered or wetted with water before it will harden or set up and begin to develop the strength for which it is famous. It may not be so well known that the amount of water used in practically all concrete is much greater than the minimum amount needed to hydrate the cement. The only reason for adding additional water is to make the mix sufficiently workable. Innumerable investigations and countless numbers of tests over many years have demonstrated that the best concrete is obtained when the water content is at the lowest point which will permit the mixture to be handled and put into place. Reducing the amount of mixing water not only provides stronger

Another consequence of slab curling is shown in Figures 8, 9, 10 and 11. When pavement slabs curl upward at the joints a space is left between the underside of the slab and the subgrade (Fig. 8). During wet weather this space usually becomes filled with water and it may be mentioned here that no means have yet been developed for positively maintaining a seal in the joints of a concrete pavement subjected to traffic, and even if it were possible water could still enter from the edges of the pavement or from the soil below. With each passage of a heavy load water is squeezed out and in the process flows very rapidly across the underlying subgrade, developing a powerful erosive action. As a result of this pumping or churning action the subgrade material is eroded away and pumped out through the joint (Fig. 9) or along the edges (Fig. 10) leaving a cavity beneath the pavement. There is also evidence that soil materials, especially the coarser grains, are transferred across the joint from one side to the other. This deposit may tend to support one end of the slab in an elevated position while the other is permitted to settle, creating a faulted joint (Fig. 11).

←Figure 10

↓Figure 11



concrete but concrete that is much denser and which offers greater resistance to the absorption of water after it is in place. As stated above, one of the principal weaknesses of concrete is its tendency to contract or expand and this tendency can be minimized by each of the following steps or precautions:

1. Use an aggregate gradation which will make workable concrete with the least amount of water. This is both an art and a science.

2. Make sure that both the sand and the coarse aggregates are clean and that there is no clay present.

3. Use portland cement that is low in tricalcium aluminate and low in alkalies. Such cements are readily obtained by specifying that the cement should be Type II, low-alkali.

4. The portland cement should have the optimum amount of gypsum which varies for different cements.

5. Make sure that the concrete is thoroughly compacted and all large air bubbles eliminated so far as possible.

6. Protect the concrete while curing, either by keeping the surface continually covered with water or with a protective coating which will prevent the evaporation of water. (MORE)

CLASSIFICATION OF PAVEMENT FAULTS

1. Inadequacies in properties of concrete

DISINTEGRATION—causes are:
Alkali agg. reaction Freezing Sulphate attack

CRACKING—causes are:
Volume change Heavy loads Alkali agg. reaction

WARPING AND CURLING OF SLAB—causes are:
Moisture Temperature Lack of restraint

2. Lack of "team work" between pavement & base

FAULTING—causes are:
Curling slabs Erodible subgrade soil Heavy traffic

CRACKING—causes are:
Resilient foundation Heavy loads
Low friction between slab and subgrade

3. Weakness in base, subbase or underlying soils

CRACKING—causes are:
Yielding foundation Heavy loads

BREAK THROUGH—causes are:
Weak foundation Heavy loads

MARKED ELEVATION OF JOINTS—causes are:
Expansive soils Non-uniform infiltration of water

These rules are all relatively simple and not at all difficult to put into effect. Nevertheless, many of them are often overlooked or ignored and concrete pavement slabs do not always perform as well as should be expected.

From the viewpoint of the materials engineer, there appears to be at times a tendency for those engaged in design or planning to regard detailed quality specifications as nuisances. There seems to be a fear in some cases that too rigid or restrictive requirements will frighten contractors into higher bids. Those in charge of construction work also have many things to think about and there is a rather widespread tendency to leave the control testing to the youngest and least experienced men on the resident engineer's crew. The scope of individual responsibility and authority inevitably varies considerably between different pavement building organizations but nevertheless it must be somehow borne in mind that the final product of all the efforts of planners and designers is the pavement itself. If the materials are not properly combined and uniform control maintained, all of the efforts spent in planning and design can be wasted.

It is obvious, of course, that the greatest assurance of success is achieved by teamwork among all of the various specialists who may be involved. It is inescapable, however, that questions of quality are never settled until the construction engineer has completed his phase of the operation, and it is often possible for the construction men to turn out a good job in spite of difficulties and limitations in materials or the preliminary plans and specifications. END

Figure 12

After the erosion and loss of material has proceeded far enough the slabs usually break transversely at a point between five and seven feet beyond the joint, Figures 12 and 13.

Figure 13

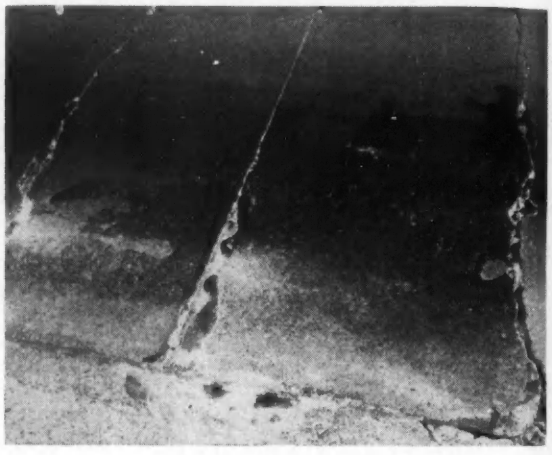
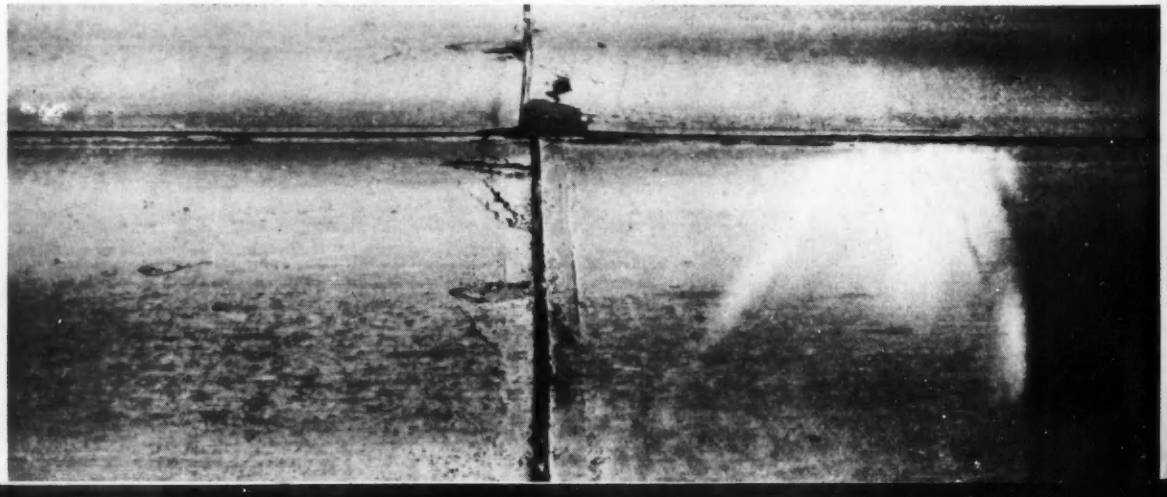


Figure 14

Another type of distress is shown in Figure 14. Here the pavement edges are broken back and wedge shaped pieces often become detached to develop what is know as spalling. Shear failures of this type also occur at the bottom of the slab but, of course, are not often observed unless the slabs are taken up or otherwise exposed to view. Perhaps the most common cause for this sort of thing is infiltration of sand, gravel or other uncompressible material. The vertical movement of the joints due to changes in temperature and moisture causes the joints to open wider at the top than at the bottom. Upon closing, the joint acts something like a rock crusher or a nut cracker and the concrete is usually unable to withstand these local concentrated pressures and spalling is the result. The solution here is to keep the pavement clean of all granular material, or if this is not possible, the joints should be filled with a rubber-like or plastic substance that will adhere to the concrete, be sufficiently compressible and elastic to accommodate the normal movement at the joint and at the same time be firm enough to prevent the embedment of coarse sand or small stone particles.



Another advance in concrete construction . . .

HIGH STRENGTH REINFORCING BARS

THE GREAT FORWARD STRIDES that concrete construction has experienced in recent years have been largely due to the use of improved materials. The development of higher strength steel and concrete, for example, made prestressing possible. A new development that promises to increase the economy of conventionally reinforced concrete is the application of high strength reinforcement; that is, bars having a yield strength over 50,000 psi. (Three classes of rebars are now commonly used: structural grade—30,000 psi yield point; intermediate grade—40,000 psi yield point; and hard steel—50,000 psi yield point). Such high strength reinforcing would mean smaller members, lower costs and more attractive structures. These advantages would be especially important in heavily loaded buildings and bridges.

European designers have been using high strength reinforcement for some time now and have found it to be both practical and economical. American engineers considered the possibility many years ago but rejected it because bond was uncertain, crack formation was thought to be increased, and there was a strong prejudice against high yield point strengths achieved through cold working of the steel. Although more investigation is necessary, it is now believed that deformed bars develop enough bond with concrete to eliminate the possibility of pull-out under high stresses. Tests are underway to determine the nature of cracks that will be encountered with high strength rebars. In conventionally reinforced concrete, the member must deflect somewhat (and therefore crack) before the tensile or stretching forces can be transferred to the steel. With high yield point steel it might take more bending for the steel to be brought into play. If the cracks are too wide, an excessive amount of water could penetrate into the member resulting in rusting of the steel and deterioration of the concrete. Experience in Europe tends to indicate that this problem will not be serious. One possibility is the use of smaller, more numerous bars.

There are two ways of manufacturing high yield point steel (steel that "gives" or starts elongating at a rapid rate only at high stresses). The low cost technique is by a process called cold working. Unfortunately, cold worked steel has an ultimate strength (point at which complete failure occurs) only slightly above its yield point. This means that there isn't much of a safety factor. The other type is called a "naturally hard" steel that owes its great strength to a high carbon content and special alloys. Using the latter process, Swedish steel mills have produced rebars with yield points as high as 100,000 psi. But the naturally hard steels are comparatively expensive.

A big hurdle in this country will be the building codes. For the more expensive high strength bars to demonstrate their economic advantages, building codes will have to be modified to permit higher working stresses. Since Europeans have been using working stresses of about 50,000 psi safely for a number of years, it seems probable that it will be possible to convince building code officials that the change is logical and workable, especially when tests are completed to clear up certain hazy areas such as crack size and bond development.

High strength reinforcement has already been used in the United States in the construction of laboratory buildings for the Portland Cement Association in Skokie, Illinois. These structures were built with a low alloy steel of 75,000 psi yield point. The engineers used a working stress of 40,000 psi. Although relatively new, the buildings appear to be performing admirably.

It seems virtually certain that high strength reinforcement will soon take its place beside such recent developments as thin shells, ultimate strength design and prestressing as one of the factors accounting for the tremendous upsurge in concrete construction activity in this country. END

MOVE Reinforced Concrete Stands To Enlarge Football Stadium

THE DECISION TO MOVE the reinforced concrete stands at Texas Technological College's football stadium 226 feet eastward as a part of an expansion program jolted many a Monday morning quarterback. And not a few sidewalk superintendents, plus a good many professionals, vowed they would never sit in those stands again. But the seven sections of concrete and steel weighing 3,200 tons have been moved, placed on new foundations, and are ready for the kick-off—and without a single crack.

It's the first time, veteran moving engineers say, that such a concrete stadium has been moved. And the moving provided a weeks-long post-season attraction.

This year's phase of the expansion calls for increasing the seating capacity from 27,500 to 41,500 and it is being done by moving the east stands further eastward, lowering the playing field 30 feet, and adding more concrete seats along the walls down to the playing level.

The moving portion of the project was done by an Indianapolis firm of moving engineers, LaPlant-Adair Company, a firm which has moved seven-story buildings, bridges upstream, water towers, and even towns.

When the final gun sounded, ending the regular football season last fall, the moving company's engineers had already begun the moving preliminaries. They began with the center section and worked toward the outer sections because each section was wider at the back than at the front and sat at an angle facing slightly toward the center of the playing field.

Procedure for moving a section began with laying three to four sets of track, depending upon

FILE: Job Practices

the size of the section to be moved. Conventional railroad track was used, with two rails to each track. It was laid on the same grade as the new site, firmly supported by cross ties and beams. The tracks ran all the way from the original site to the new site.

Big steel beams, which movers called "main runs," were installed length-wise under the section and directly over the track. After they were leveled, more steel beams (called "cross sills") were installed resting on the main runs and reaching across the section at right angles to the main runs.

Then came the placing of the "shoes," which resemble the bottoms of sleds with the fronts turned up. They fitted underneath the main runs and rode on rollers placed along the tracks.

On opposite sides of each of the concrete columns which support the section were placed still shorter steel beams, the "needles." Big wood ties, four to each concrete column (two on each needle) were placed on end on the needles and clamped against the stadium columns. Four gigantic clamps squeezed the wood ties against each column, holding the weight by friction and transferring it onto the needles.

"Our engineering estimates showed that about two and a half clamps per column would have been sufficient to lift the sections," Engineer Ed Paschau said, "but we used four to provide more than enough margin of safety."

The weight was transferred from the needles onto the cross sills, then to the main runs. At that stage, wooden wedges were driven in between the shoes and the main run until the load was picked up, after which columns were cut off from their old foundations beneath the grip and the section was ready to roll.

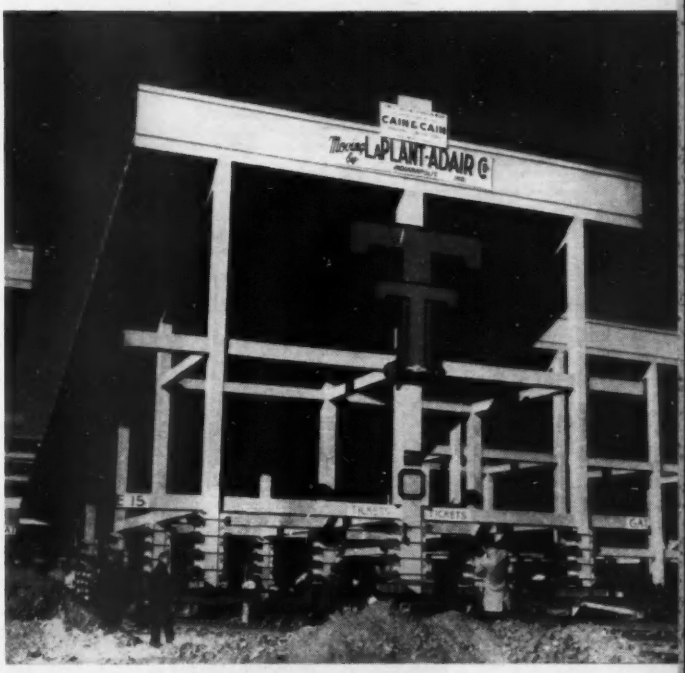
A surprisingly small winch truck with a ⅝-inch cable pulled the section over the hundreds of 2-inch rollers between the shoes and the double tracks. When everything was in readiness for the first section to be moved, the weather was checked, and the day set, with plenty of advance publicity.

A football game crowd was on hand early on moving day. It was a crisp, clear day and engineers planned an early start, because they wanted to move and spot the section in one day, to avoid any weather interference.

When the engineers made their final checks and gave the order, the middle section was moved, at first so slowly it was hardly noticeable, except in relation to the adjoining sections. The truck pulled it about two inches on the first tug. From that moment on, it was almost a breeze.

Engineers took their bearings again; the second movement was about two feet; and seven hours later the big center section had been spotted 226 feet behind the remainder of the east stands over previously completed new concrete foundations.

The six other sections followed, a week to ten days apart, the time depending mostly on weather conditions. The actual moving, in the case of every section was completed within a day. The placing of concrete for the additional seating is now in progress. END



OPPOSITE PAGE: This aerial photo of Texas Technological College's football stadium was taken after the middle section of the east stands and an adjoining section had been moved backward 226 feet to their new location. Moving contractors moved the remainder of the east stands, section at a time, working toward the right to the end, then toward the left. Excavations which will lower the playing field approximately 30 feet also are underway. Additional seats are being added from the front rows of the present stands almost down to the new playing level.

RIGHT: This close-up shows how each section was grasped by clamps against the columns, transferring the weight onto steel beams resting on other beams which ride on steel shoes rolling over tracks. A winch truck with a ⅝-inch cable did the actual pulling.

concrete construction firsts in the United States

Ever wonder how a particular job of yours stacked up against the first of its kind? Americans have traditionally been keenly competitive in matters of priority. Perhaps this accounts for the great number of record setting construction projects in this country despite stiff building code provisions. Listed below are the oldest concrete projects in this country. As far as we can determine they hold the records in their respective areas.

We delved fairly deep into the records to come up with these projects. Our list of "firsts" should be unassailable, but it's entirely possible that it may be incomplete or incorrect. If you are aware of any jobs that preceded these, or if you know of other concrete construction "firsts," we would appreciate hearing from you. All letters on this subject will be published. With the science of concrete construction advancing at such dizzy speed in recent years, you may know of some record breakers for size as well as for priority.

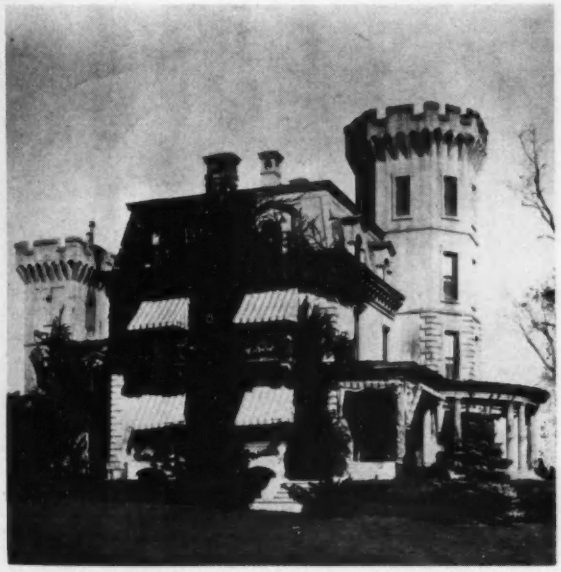
PRESTRESSED BRIDGE: Site-cast girders spanning 160 feet rendered the center span of the Walnut Lane Bridge, Philadelphia, Pennsylvania, first prestressed bridge undertaken in this country, the longest span for a number of years.

CONCRETE BRIDGE: Built before the turn of the century in 1889, when reinforced concrete was still in its infancy, a single span arch bridge in Golden Gate Park, San Francisco, California, became the first concrete bridge constructed in the United States.

CONCRETE PUBLIC BUILDING: Although a few private homes had been built of reinforced concrete considerably earlier, it wasn't until 1889 that the first public concrete building was constructed in the United States. In that year Ernest L. Ransome, famed builder, dared to employ concrete for the Leland Stanford Museum, Palo Alto, California. It was one of the few buildings to withstand the great earthquake and fire of 1906 and it is still standing as evidence of the durability of concrete.

FILE: History

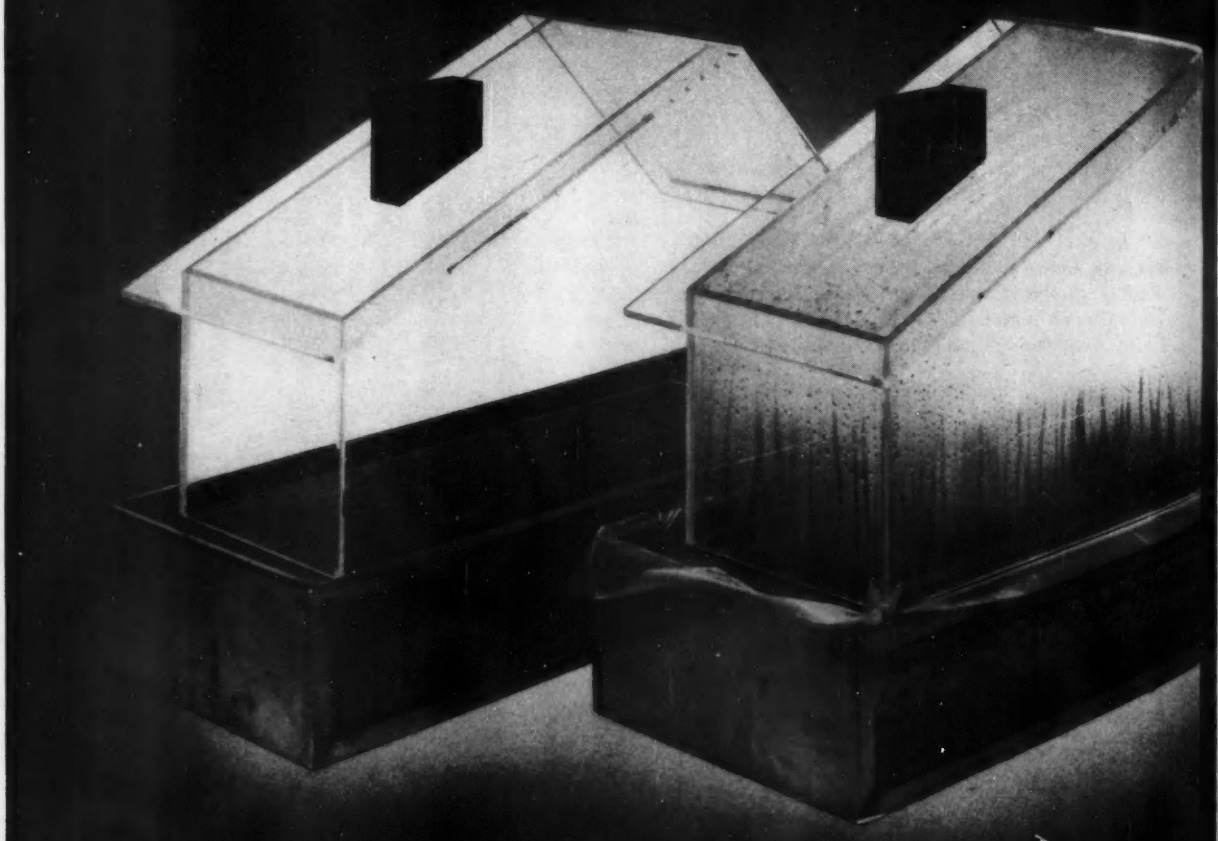
CONCRETE SKYSCRAPER: The Ingalls Building in Cincinnati, Ohio, built in 1902 by the Ferro-Concrete Construction Company, was the first American concrete skyscraper. Rising 210 feet for its 16 stories, it marked the emergence of the then relatively new concept of reinforced concrete as a trusted material of construction. This building is also still in active use.



CONCRETE HOUSE: Probably the first reinforced concrete structure erected in this country was the Ward House in Port Chester, New York, in 1873. Using iron for the reinforcement, it was known as Ward's Folly as neighbors awaited its imminent collapse. By now they must be rather weary of waiting, since the house is still in use.

CONCRETE STREET: This honor is claimed for a street in Bellefontaine, Ohio, built in 1891. It was cast with waffle grooving in the surface to provide sure footing for horses. It is still serving its town well.

Will your next structure be



This structure is protected by *PM

This structure is protected (?) by a plastic vapor barrier

NOTICE THE DIFFERENCE!

Pictured above is a display that has attracted widespread attention wherever it has been exhibited. Both houses, concrete slabs and tanks are identically constructed. The tanks are filled with sand, to represent soil, and water is added. On top of the soil is placed a vapor seal . ."PM" under the house on the left and a plastic film under the house on the right. Heat is applied to the tank to accentuate the creation of vapor and the results are very apparent. Notice that the house protected by "PM" (left) is completely dry while the house on the right has become a virtual steam bath. The results are even more amazing when you consider the fact that the plastic film under the house on the right is a monolith without the seams, openings and ruptures that would be present in full-scale construction.

a virtual "steam bath"?
...not if it is protected by *PM!

Moisture migration into the structure from the site is an age old problem . . . a problem that is accentuated in today's modern buildings. Old buildings, constructed without benefit of new materials and better construction methods, permitted excessive moisture to escape. Today's tightly and expertly constructed buildings trap this moisture inside and the problems resulting from excessive moisture soon follow. Dampness, window condensation, paint failures, mildew, rust and rotting wood are all problems that can be eliminated if the structure is isolated from the site, the source of 80% of this moisture.

Fortunately, the building industry has recognized the need to install a vapor barrier . . . unfortunately, it has been guilty of the promiscuous use of permeable materials as vapor barriers. Plastic films and other similar materials would never be used to replace glass in windows because they would not eliminate weather penetration and would easily rupture. These same reasons disqualify these products as vapor barriers. Even more important, a vapor seal is installed permanently at the time of original construction . . . it cannot be replaced at a later date in case of a product failure.

A vapor seal must be impermeable; monolithic without voids, open or lapped seams and strong enough to provide a permanent installation without rupturing under installation foot traffic, trundling of wheelbarrows and pouring of aggregate. Only *one* product on the market meets all of these necessary qualifications—"Premoulded Membrane" Vapor Seal. To prove this, we sincerely advise and invite your comparison of *PM against all other so-called vapor barrier products on the market. What could be fairer? Also important is the fact that "PM" is actually the most economical vapor seal available when you consider the possible elimination of sand and gravel fill plus the reduced maintenance and redecorating costs realized through the *complete* elimination of moisture migration into the structure.

***PM is a recognized abbreviation for *Premoulded Membrane*™, the industry's only TRUE vapor seal!**

Write today for complete information . . . request your free copy of "Design Techniques"—a technical manual that provides Architects, Engineers and Builders factual proof of the effectiveness of using impermeable materials in eliminating moisture migration. For a complete set of structural recommendations on the applications and installation of "Premoulded Membrane" request a file of "PM" Tech-Tips.

OTHER SEALTIGHT® BUILDING PRODUCTS

- "CORKTITE" Impermeable Perimeter Insulation
- "SEALTIGHT" Polyvinylchloride Waterstops
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- Joint Sealing Compounds
- Roof coatings and cement
- EXPANSION JOINTS of all types including asphalt, fibre, cork and sponge rubber.
- Plaster Board
- Sewer Joint Compounds
- Air Entraining Agents
- Concrete Curing Compounds

W. R. MEADOWS, INC.

29 KIMBALL STREET • ELGIN, ILLINOIS

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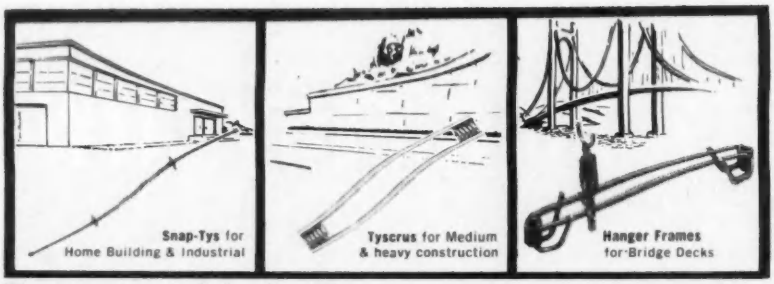
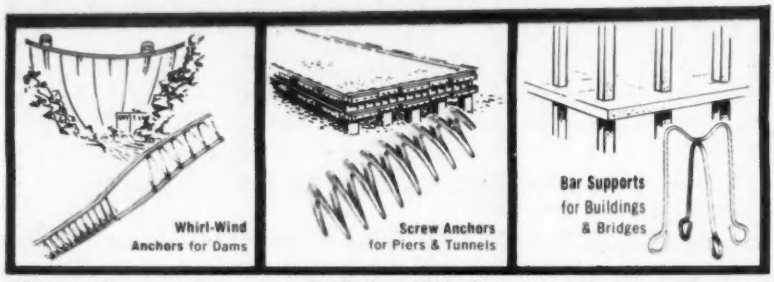
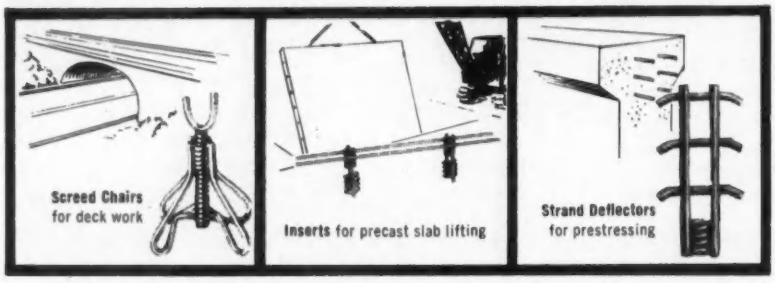


For every kind of concrete construction



there's a dependable Richmond product!



Richmond has learned, through years of practical experience and research, how to design and produce the most effective and economical form ties, anchors, inserts and accessories for every conceivable kind of concrete construction.

All Richmond-engineered products, and there are more than 400 in the complete line, are designed to provide the extra strength that assures a safe, dependable forming job while saving time and money.

In addition, Richmond's field representatives and Technical Department can help you with any problem you might encounter in planning your form work . . . and will provide you with estimates, "take-offs" and material specifications on request.

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For complete information about Richmond's full line of quality products for concrete constuction—or assistance with any specific concreting problem, write to:—

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letters

concrete and steel

Sir:

I was, of course, pleased to see the enthusiastic description of the PCA Laboratories and their work in the article "Revolution in Concrete." I am somewhat concerned, however, about a statement attributed to me, namely, "At the present time, about 5 percent of the structural material going into American buildings is concrete and the remainder is steel."

Obviously, large amounts of concrete go into the foundations, floors and fireproofing of any building, even a steel-framed one. Furthermore, since large amounts of brick and wood are used as structural materials, it is not entirely a matter of the proportion between concrete and steel.

I had mentioned as a rough estimate that only 5 to 15 percent of the framing for American one-story industrial buildings has been concrete in past years. I had also expressed a belief that this 5 to 15 percent may increase toward 50 percent in coming decades as a result of improvements in structural concrete technology, and extended use of concrete shell roofs.

I would then like to express a particular appreciation for the emphasis your article placed on quality as the keynote of the future. As I see it, an incomplete appreciation and application of known principles of quality concrete production is today the most serious force retarding further improvements in structural concrete usage.

EIVIND HOGNESTAD
Structural Development Section
Research and Development Laboratories
Portland Cement Association
Skokie, Illinois

Maginniss motor-in-head concrete vibrators—best for every job!

Use the right tool...

Skilled mechanics are careful to use the tool best suited for the job at hand. Profit-conscious contractors, too, use equal care when selecting concrete vibrating equipment.

And, because Maginniss builds both Hi-lectric induction motor-in-head vibrators for heavy work and Uni-lectric series motor-in-head vibrators for light work, you can choose the vibrating tool best suited for your construction jobs—large or small!

For better concrete . . . higher production . . . lower costs, see your Maginniss distributor. He'll recommend the Maginniss motor-in-head vibrator exactly right for your needs.

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HI-LECTRIC vibrators, featuring powerful induction motor-in-head design, are ideal for continuous use in heaviest service. Use them on bridges, culverts, heavy structures of all types and on paving jobs.

UNI-LECTRIC series motor-in-head vibrators use available 110 volt current. For sound, better looking concrete, use them on footers, curbs and gutters, thin walls, drives, floors, repairs—any light job.

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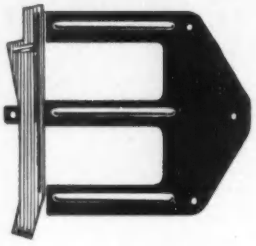

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The MODERN method of supporting walers on wood forms designed and engineered to give maximum performance and safety.

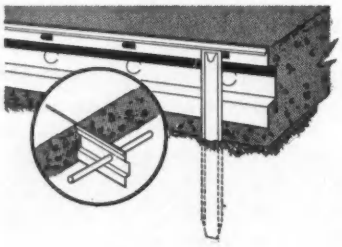
Vines Waler Brackets successfully support, space and retain walers independently of wall ties or clamps without toe nailing to studs and meet the requirements of the contractors and the safety engineer.

BURKE HANDY REEL

- Solid continuous aluminum frame.
- Self locking pin.
- Reversible belt loop for right or left hand workers.

Finger tight screw means:

No wrenches to use . . . no parts to lose . . . no threads to strip. Easy to rewind.



KEYED KOLD JOINT FORMS

A new concrete construction product that serves as form, screed, and true cold joint, left permanently in the concrete floor slab. The use of Keyed Kold Joint eliminates spalled joints . . . produces a cold joint structurally sound and architecturally beautiful. Keyed Kold Joint also eliminates costly make-up and stripping of split forms for checkerboarding. Saves up to 35% in cold joint form costs . . . results in neater, uniform joints.

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Please Send Me the Following:

☐ Free Brochures
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☐ 1. Vines Waler Bracket
☐ 2. Burke Handy Reel
☐ 3. Keyed Kold Joint Forms

Firm Name_____ Your Name_____

Address _____

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NCCA conducts membership drive

The National Concrete Contractors Association, with the belief that concrete contractors can play a tremendous part in shaping the conditions under which they work, is conducting an intensive membership drive.

The NCCA is designed to insure broad benefits for its members, primarily in the fields of research, product promotion and public relations.

It has begun to conduct national surveys which will enable it to act as a clearing house for information on such subjects as union contracts, pension and welfare plans, industrial promotion funds and business standards and policies.

The potential of concrete is practically unlimited, but the NCCA believes that a national organization is necessary to promote its broader use by architects, engineers and specifications writers.

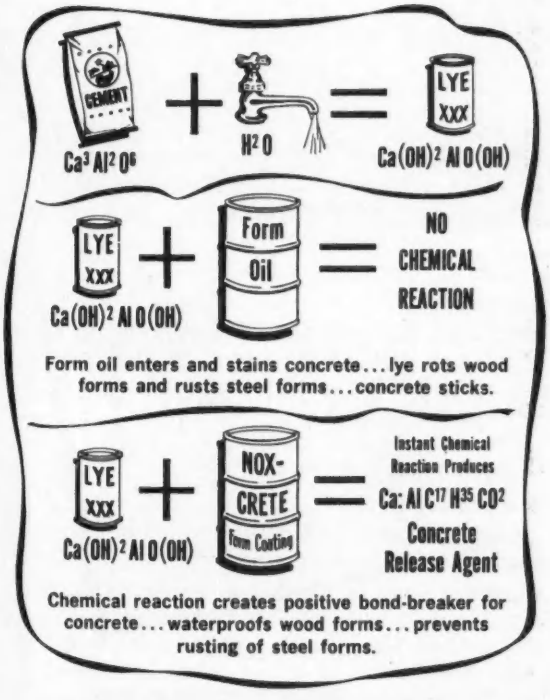
The Association's public relations program is designed to achieve national recognition for concrete contractors, both as individuals and as an organization.

For the Association to do the job it has set out to do and to carry the necessary weight in the councils of the construction industry, its membership must be truly representative of the concrete construction industry throughout the United States.

Readers of Concrete Construction who are interested in learning more about membership in the NCCA may request information by filling in the Association's special self addressed card in the center spread of this issue.

Cut Form Costs!

Use a Chemical Reaction, Not a Lubricant, as your Concrete Bond-Breaker


CEMENT
$Ca^3 Al^2 O^6$
$H^2 O$
LYE XXX
$Ca(OH)^2 Al O(OH)$
LYE XXX
$Ca(OH)^2 Al O(OH)$
Form Oil
NO CHEMICAL REACTION
Form oil enters and stains concrete... lye rots wood forms and rusts steel forms... concrete sticks.
LYE XXX
$Ca(OH)^2 Al O(OH)$
NOX-CRETE Form Coating
Instant Chemical Reaction Produces
Ca: $Al C^{17} H^{35} CO^2$
Concrete Release Agent
Chemical reaction creates positive bond-breaker for concrete... waterproofs wood forms... prevents rusting of steel forms.

NOX-CRETE* FORM COATING reacts chemically with concrete mix to prevent bonding between poured concrete and the inner surfaces of forms or moulds, producing a smooth, high white, flat concrete surface essentially free of voids and one which bonds readily with concrete paints and cement coating. Moreover, the by-products of this chemical reaction waterproof wood forms and act as rust-preventives on steel.

COSTS LESS TO USE—because the concrete mix itself supplies half the materials for the chemical reaction, Nox-Crete Form Coating covers up to twice as much surface as ordinary form oil, depending upon method of application. Form-cleaning is reduced to a minimum... life of wood forms is more than doubled... maintenance costs on patent forms is reduced by 50%... fibre tube and box forms strip easily. Nox-Crete Form Coating sprays readily even at below-freezing temperatures—forms can be used minutes or weeks after spraying. Write today for data sheets, name of nearby distributor, and list of contractors in your area who are now using Nox-Crete Form Coating.

THE NOX-CRETE COMPANY
Omaha, Nebraska

NOX-CRETE* FORM COATING

The Original Chemical Bond-Breaker for Concrete

**Registered Trade Mark*

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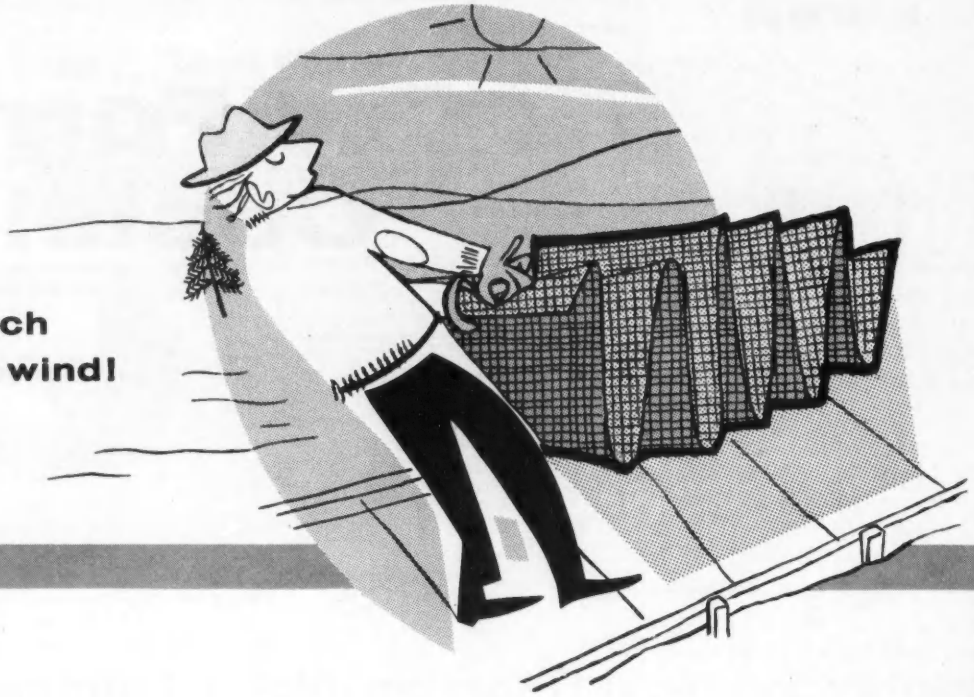

For quality concrete...

make sure it's protected from drying winds!

Hot weather or cold, even a light wind can increase evaporation rates to critical levels. Curing of concrete stops—quality suffers.

In windy weather, protect concrete *during* placing with windbreaks—even well before you are ready to begin curing. And *start* curing as soon as possible.

For quality concrete every time, keep crews informed of facts like these. You can do it conveniently and dramatically with this set of 4 posters. They cover heat, freezing, wind and excess water. Fill in the coupon below for your set.

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A national organization to improve and extend the uses of concrete

Please send a free set of Quality Reminder posters. I could also make use of ( ) additional sets.

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Your name_____

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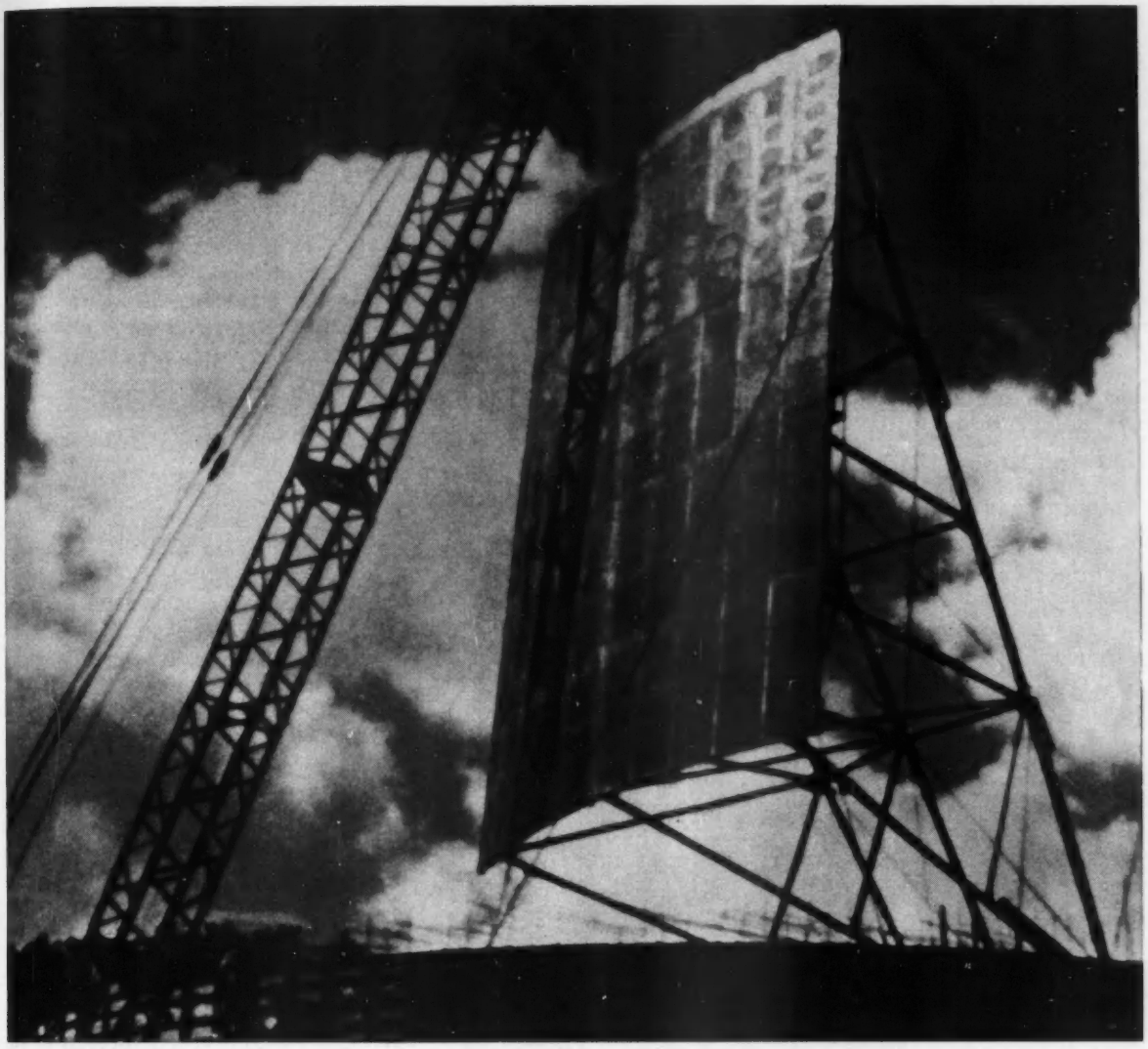

4 Ton Ganged Section, 22 Ft. by 28 Ft. Used for . . .

28′ High Circular Walls of Sewage Plant

Friebel & Hartman, Shelby, Ohio contractor, was able to strip and reset 2,300 square feet of forms on the inside gang section in 3½ hours. A ¾ yard crane with an 80′ boom handled the sections. 8 men in less than 8 hours erected 2,300 square feet of forms and scaffolding on the outside, plus pouring the concrete. The project was the Mansfield, Ohio Sewage Treatment Plant, which consisted of four digestors, each 80 feet in diameter, 28 feet in height and 8 inches thick with no horizontal joints.

Four ganged sections were used—each 22 feet wide and 28 feet high. This allowed pouring ⅓ of a tank at a time, and a pour every four working days. Weight of each ganged form section was about four tons. By using three trusses to brace each ganged section contractor was able to hold bracing costs to a minimum.

Complete story on the Ohio Sewage Treatment Plant will be sent *free* upon request. Symons Steel-Ply Forms can be rented with purchase option.

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letters

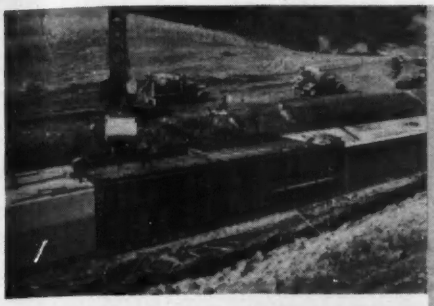
against purchase requisitions

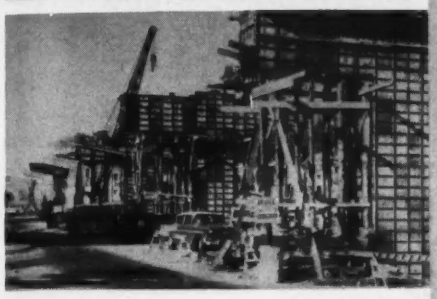
Sir:

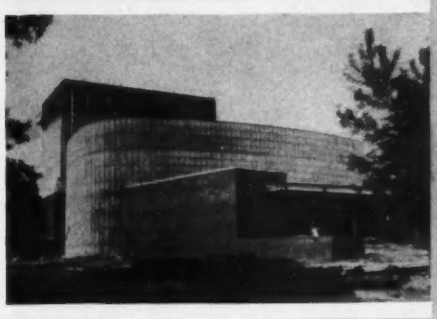
I read with much interest and complete disagreement the letter of Mr. G. Szmak, Executive Secretary, Construction Surveyors Institute, which was published in your June, 1960, issue, under the caption "Improving Bidding Practices." Purchase requisitions are "old hat." I have participated in discussions with others in the industry on this subject at different times, the first time being probably 25 years ago. Each time the same conclusion was reached —negative. The contractors I have talked to have many reasons for rejecting this method, the most important of which is, and with which I agree, that unless a contractor makes his own quantity survey from which he obviously becomes intimately acquainted with the nature of the work involved, he cannot price his job properly particularly with respect to methods and labor cost.

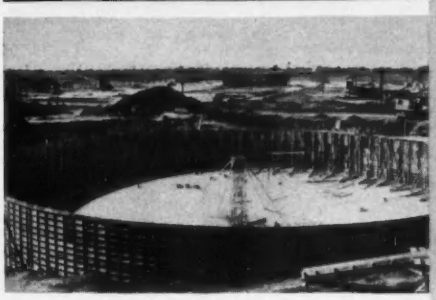
Nor does Mr. Szmak explain how the use of purchase requisitions changes in any way the value of the given piece of work, or the severity of competition, when such are the prevailing conditions in the market. What I think he completely overlooks is the fact that prices are either good, fair or impossible, depending upon the ratio of the industry's capacity to the aggregate volume available. When this ratio is favorable it is evidenced by the fact that each job has only a few bidders seeking it, whereas when this ratio is unfavorable the list of bidders is long. It is therefore my opinion that regardless of what method is used in compiling the price for a job, the prevailing market conditions will govern whether the industry is thriving or financially unhealthy. ·

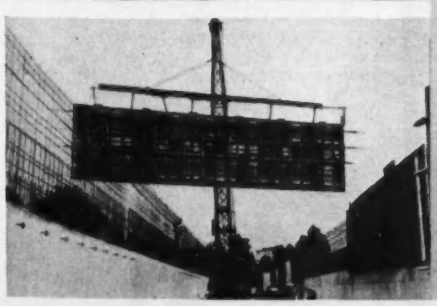
(MORE)











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All of this results from the forces constantly at work under our free enterprise system. The New Deal, Fair Deal, or any other Deal has no effect upon the law of supply and demand. When contractors have insufficient work available to them they are hungry and the prices reflect this. Conversely, when contractors are scarce because of extremely large volumes available to them, prices are fair. And, may I add, it is my hope that nothing will be done in an effort to change the free enterprise system even though we suffer from the same unfavorable market conditions prevailing as others do at this time.

Nor do I understand Mr. Szmak's inferences relating to the letting of Public Works contracts. Is there any other way than the prevailing practices which would still be fair not only to the contractors competing against each other, but also, and more important, to the public?

If Mr. Szmak's purpose is to encourage a wider use of the services of construction surveyors, I certainly can find no fault with this. Each business organization must be aggressive in its way to expand its volume of business. However, if this is Mr. Szmak's objective he should find better reasons than those given in his letter in reference.

I. Roy Psaty
President
Psaty & Fuhrman, Inc.
Contractors and Engineers
New York, N. Y.

P. S. I forgot to mention, some years ago when the British Construction Team was visiting in this country, I had the pleasure of taking them through one of the jobs we had under construction. They informed me at that time of the British Purchase Requisitions system. They were most critical of it for many reasons, one of which was the fact that it delayed their payments excessively. Although, as you know, payments are slow enough in this country on Public Works, they are received very quickly by comparison with the British system.

Concrete Construction expresses its appreciation to Mr. Hognestad (page 230) and to Mr. Psaty for their letters published in this issue, and to other readers whose letters have appeared in the past. Comments of this sort are helpful to all of us, and readers are always welcome to send them along.

EDITOR

TRIPLE THREAT TEAM

CHALLENGE "INSTANT-TROWEL"

Challenge offers THREE practical sizes of Tri-Blade INSTANT TROWELS that give you perfect concrete finishing . . . faster . . . easier. Faster, easier floating and finishing . . . faster on and off the job . . . easier on the operator . . . easier on the machine tool

- No shoving . . . tugging . . . pushing . . . just smooth, vibrationless action from float to finish.
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- More RPM's at your command . . . 145 instead of only 70-110 . . . up to 45% FASTER finishing! Yet plenty of torque for slow-speed floating.

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CP CONCRETE VIBRATORS GIVE YOU ALL THESE ADVANTAGES

- The most powerful vibrator on the market. Places more concrete per hour than any other vibrator of comparable size.
- Electro-geared, variable speed. Hicycle Motor delivers 10,000 V.P.M. . . . simple lever movement on generator permits reduction of power and frequency to prevent over-vibration in high slump concrete or thin wall sections.
- Motor-in-head design permits one-man operation — means only the vibrator is up on the form. Generator can be located up to 200 feet away.
- Small head diameters — 1¾" and 2⅜" — light weight, easy to maneuver.

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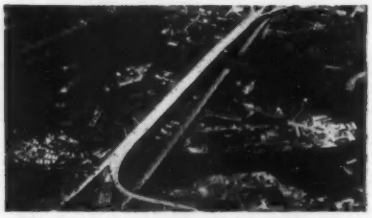
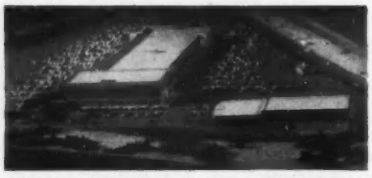
WELD-CRETE®

Weld-Crete is the patented, job-proved liquid bonding agent which enables you to *permanently* bond new concrete, or cement plaster, *directly* to any other structurally sound surface no matter how smooth! No costly, time-consuming surface preparation. Just apply, let dry, and pour or trowel new concrete. Ideal for new construction, remodeling, repairs . . . *ramps, floors, precast shapes, driveways, highways, walls, machine mounts and pads.* Weld-Crete has equal bonding permanence all climates, all surfaces, all sorts of conditions. When used with quick setting cement topping you can lay new floors, ramps, driveways one day and run heavy truck traffic over them the next. Get fact-packed literature from your Building Materials Dealer, see Sweet's File, or write us direct. Address Larsen Products Corporation, P.O. Drawer 5938, Bethesda, Maryland.

Typical **WELD-CRETE** Applications



GRANVILLE ST. BRIDGE, VANCOUVER, BRITISH COLUMBIA—One of the largest 8 lane bridges in North America. Here Weld-Crete was applied to bridge surface to bond cement dividing strips. Now, over 4 years later, bonds are as good as new. *General Contractor:* Dominion Bridge Company.



SEVEN CORNERS SHOPPING CENTER, FALLS CHURCH, VIRGINIA—During construction of this 600,000 sq. ft. structure, initially only part of floor was poured and floated to a smooth finish. Areas in which show windows would be added were poured as base slab only. Slab was coated with Weld-Crete. After store fronts were custom-built, delayed toppings of 1" to 1½" thick were poured with assurance of permanent bond to base slab. These toppings were then finished with asphalt tile, wood, or finish flooring of lessee's choice. Designed and constructed by The Kass Realty Co. of the Kass-Berger Organization under direction of J. Franklin Groff. *Concrete Contractor:* Moses-Ekco.

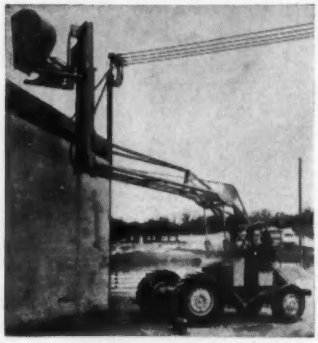
Circle 812 on reader card.

products

For additional information circle matching key number on reader service card on page 232B.

concrete bucket 827

This ⅜-cubic-yard concrete swivel bucket mounted on a Lull 7B Hi-Lift permits operator to travel parallel to forms and discharge load to either side. The



bucket shown is dumping at a 45-degree angle; it can dump up to a 90-degree angle to the right or left. Dumping is completely controlled from operator's seat. Lull Engineering Co., 3045 Highway 13, St. Paul, Minn.

anti-slip coating 828

Application of an anti-slip coating in industrial, commercial and home areas is described in booklet I-F8-C. Available in 5 colors, it can be used in plants, buses and trucks, stadiums and swimming pools. It is applied either with trowel or spray. Industrial Products Div., Flintkote Co., 30 Rockefeller Plaza, New York, N. Y.

sling chain safety 829

A 6-part kit on sling chain safety provides safety directors, plant men, purchasing agents and anyone else involved in the purchasing, servicing and use of chain for materials handling answers to almost every question regarding the care, use and inspection of sling chains. McKay Company, 1005 Liberty Ave., Pittsburgh, Penna.

diamond drill 830

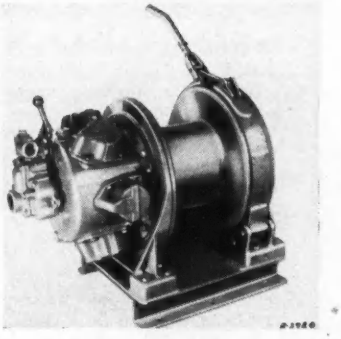
The cost of drilling in reinforced concrete, brick, stone, tile, and other hard or brittle materials is substantially reduced by diamond drilling equipment. Neat holes require no patching. Air motors and electric motors are interchangeable on a swivel drill, 6-inch capacity, that drills holes at any angle. E. J. Longyear Co., 76 S. 8th St., Minneapolis, Minn.

overlaid plywood 831

A booklet explains how high density overlaid plywood is manufactured and lists case histories of end uses of this plastic covered building material. Recommended for concrete forms, moisture proof containers, highway signs and industrial sidings and wall linings. Kimberly-Clark Corp., Neenah, Wisc.

utility hoist 832

Single drum air powered utility hoist capable of handling a maximum load of 7000 pounds retains the same portability and adaptability of smaller units. Designed to handle heavier loads on erec-

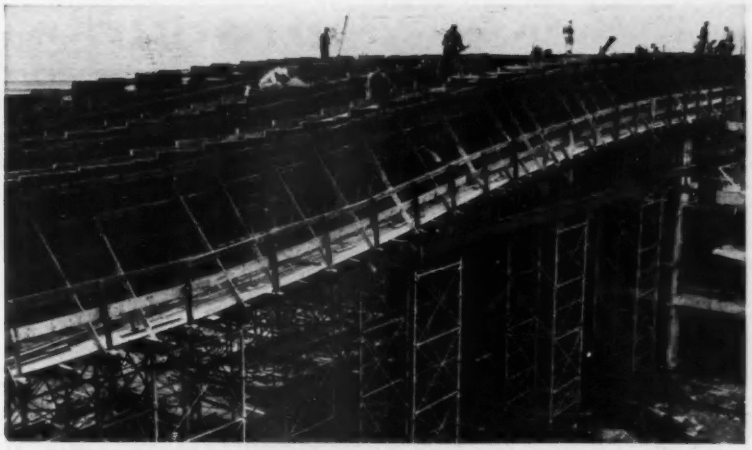


tion, maintenance and materials handling jobs without multiple reeving, hoist is adaptable to wall or ceiling mounting, as well as the conventional floor mounting. Ingersoll-Rand, 11 Broadway, New York, N. Y.

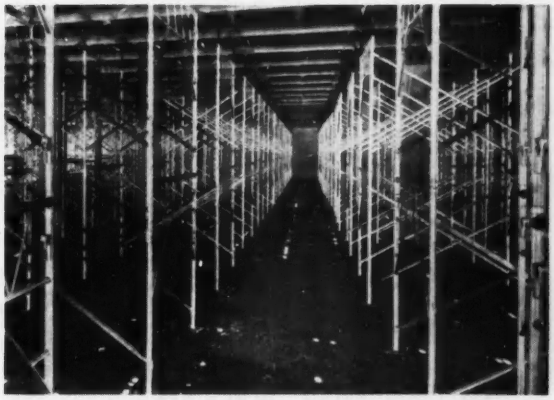
Shoring Methods

for concrete construction

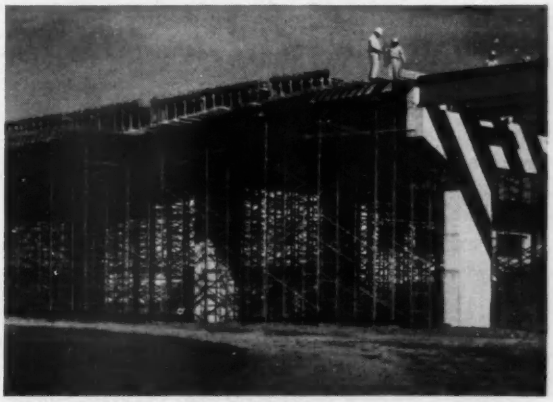
. . . by Patent Scaffolding CO.



EXTRA HEAVY DUTY SHORING Rolls to Pours—Mounted on a traveller, each Extra Heavy Duty Shoring set-up supports two of 16 clear-span concrete girders from 7′8″ to 8′8″ deep, 2′ to 2′10″ wide, and 125′ long, at Eastern Airlines Terminal Bldg., Idlewild Airport, N.Y. Gilbane Building Co., gen. contr., pours a pair of girders, lowers shoring and rolls it to new positions.



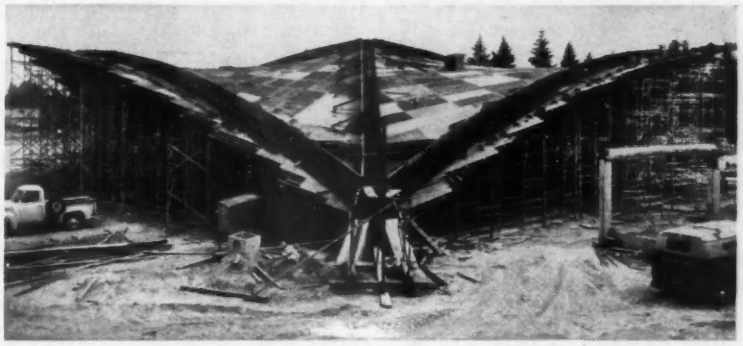
STANDARD SHORING Meets Most Job Needs—Standard "Trouble Saver" Shoring 5′-wide frames are assembled rapidly to provide safe, ample support for pan construction of the Atomics International Project, Canoga Park, Calif. Shoring supports 30″ x 30″ x 14″ domes with 4½″ slab. C. L. Peck Construction and Realty Co., general contractor.



NEW HEAVY DUTY SHORING Supports Bridge—Safe support for the heavy loads imposed by this concrete overpass in San Jose, Calif., is provided by new PS Co. 4′-wide Heavy Duty Shoring frames, tested under simulated field conditions to safely support loads up to 10,000 lbs. on each leg. General contractor, Oscar C. Holmes.

STANDARD FRAMES SHORE HYPERBOLIC PARABOLOID STRUCTURE—

On the new auditorium for Edward S. Ingraham H. S., Seattle, Sound Construction Co., general contractor, uses 1300 standard "Trouble Saver" Shoring frames to support dome and slab formwork for this concrete hyperbolic paraboloid structure. Design involves three anchors, set 161′ apart, from which three center beams, 2′6″ x 4″, arch to 35′ high. Two perimeter beams per anchor fan out and intersect at 28′ high.



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SALES RENTALS

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products

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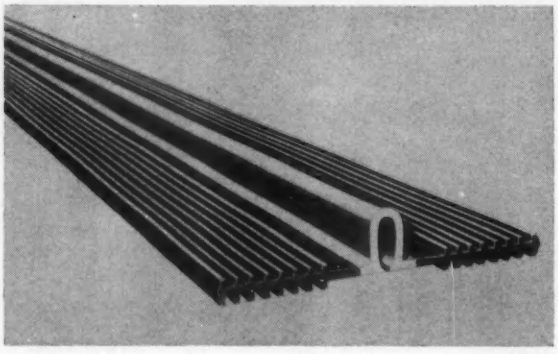
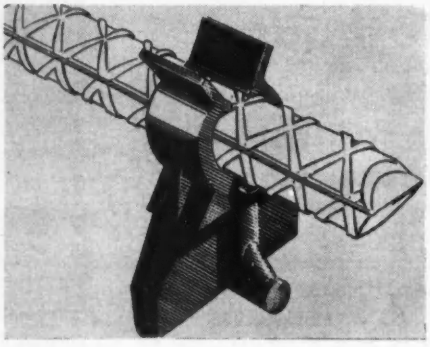


waterstop **833**

Waterstop is extruded simultaneously from two PVC compounds, that in the center area compounded to combine strength with maximum flexibility, and that in the multiple-rib area compounded to offer strength with a desirable rigidity. U-bulb center area expands mechanically up to 1½ inches. Opening to U-bulb is protected by a thin membrane which prevents infiltration of concrete during placing and subsequently tears to accommodate expansion. W. R. Meadows, 26 Kimball St., Elgin, Ill.



bar support **834**

Solid polyethylene bar support is designed to hold reinforcing bars in sizes from No. 3 to No. 9 in slabs, columns and beams, both in the plant and on the job. The bar is easily snapped into place, and rigidly maintains utmost stability under normal placing conditions, according to the manufacturer. Device is said to be impervious to corrosion and is guaranteed rust-free. Heights range from ½ inch to 1½ inches. Universal Builders Supply Co., 787 United Nations Plaza, New York, N. Y.

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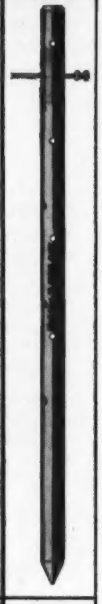

dee CONCRETE ACCESSORIES CO.
670 N. Michigan Ave., Chicago 11, Illinois

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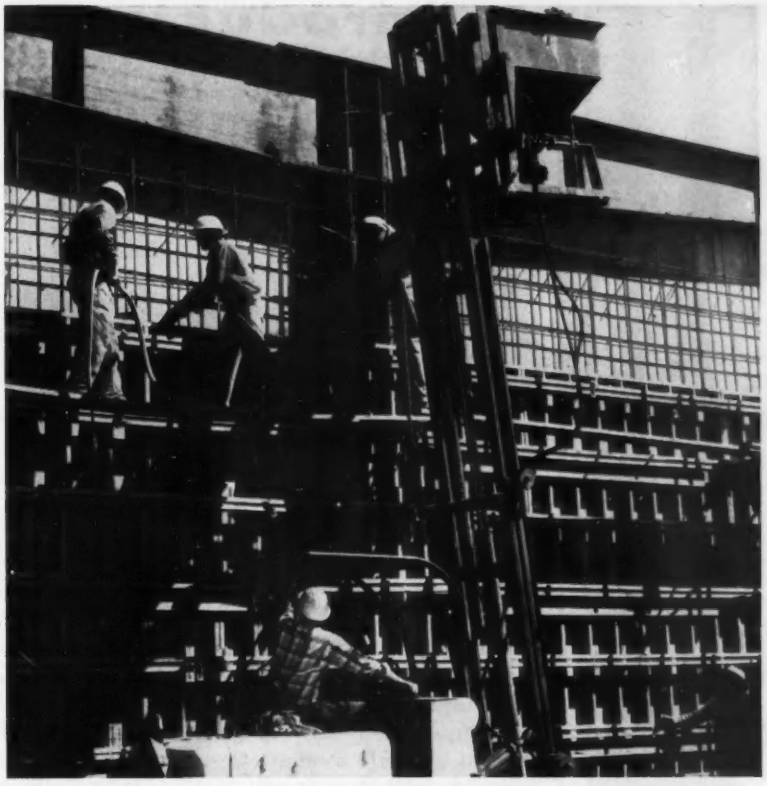

CONCRETE GOES DOWN — ¾-yd. bucket is tripped hydraulically by lift operator. Concrete for the walls was 5½ sack with ¾" to 1½" aggregate. The fork later stripped panels.

FORMS GO UP — 8′ x 12′ panel is raised for upper lift of wall around Salinas, Calif., plant. 2 x 4 studs and double 2 x 4 walers back plywood-faced panels. Contractor: Haas & Haynie, San Francisco.

Fork lift cuts cost of poured walls

20′ CONCRETE WALLS, poured-in-place in order to meet exacting sanitary requirements for a food processing plant, were built at a cost comparable to tilt-up by using a modified fork lift truck. For the pouring, done with ready mixed concrete, the contractor required only the lift operator, one assistant and two vibrator operators.

The fork lift, fitted with a steel frame instead of arms, placed the form panels in two lifts: an 8′ x 12′ and a 4′ x 12′ section in the lower lift and an 8′ x 12′ panel in the upper lift. Both were concreted by the same fork lift, equipped with a special ¾-yd. bucket. Before the second lift was poured, the 8′ x 12′ section of the first form lift was stripped, leaving the 4′ x 12′ section in place to hold the upper form.

Concrete for the 5″ thick, 25,000 sq. ft. mezzanine floor also was poured by the fork lift. The versatile rig also was used to strip the forms, after the first panel in each series was hand-stripped.

Smoothly scheduled deliveries, and proper processing of the 1585 cu. yds. of concrete placed by the fork lift, were insured by truck mixers of certified design, capacity, mixing speed and water control accuracy.

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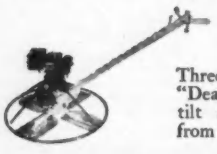
Packs three times the wallop of the 60 cycle vibrator. Powerful 1½ H.P. motor retains full power in low slump concrete. Removable motor and eccentric sections.



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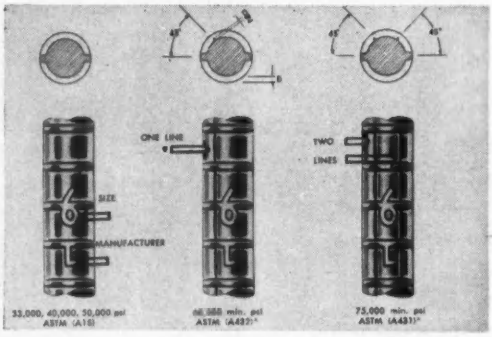

bar markings 835

High-strength multirib reinforcing bars are identified for grade by one and two longitudinal ribs, respectively, rolled into bars at time of manufacture. The identification system includes a number designating the bar size, and the letter "L" for company of origin. The use of grade identified steel in ultimate strength design offers many advantages, according to ACI Building Code authorities and designers. From 10 to 15 percent of the total construction cost of a concrete structure may be saved through the use of full strength of materials. Laclede Steel Co., Arcade Bldg., St. Louis, Mo.

water tower pad 836

Specifications for a circular, 50-foot diameter water tower pad called for a solid reinforced concrete pad 5 feet thick. A level surface, varying less than ¼ inch, was required. Forms were tied together in the usual way with braces applied to every third panel. Trucks backed directly to the side, delivering ready mixed concrete continuously from each side. Three men placed 365 cubic yards of concrete in 8½ hours. Symons Clamp & Manufacturing Co., 4249 W. Diversey Ave., Chicago, Ill.

4 hours ago, a ragged hole ➧ ➧ ➧ ➧

ON THE NEW JERSEY TURNPIKE, ILLUSTRATED ABOVE, A SIKA CREW OF 3 MEN USING SIKA EPOXY PATCHING COMPOUND AND AN ELECTRIC MIXER PATCHED 40 HOLES IN AN 8-HOUR SHIFT.

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products

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thin shell construction 837

A 24-page bulletin describes an advanced technique which allows for economic construction of thin shell buildings. It proposes the use of a foamed polystyrene plastic as a structural form board to create the desired surface previous to, and to act as a support for, the application of the structural roof material. The material is designed to remain as an integral part of the roof, providing permanent insulation, effective vapor barrier, and a base for interior decoration. Dow Chemical Co., Midland, Mich.

lifting inserts 838

Lifting inserts for precast concrete piles, beams, slabs, columns, tilt-up walls, prestressed girders and other prestressed members are described in Bulletin LIR. Tables give working loads and test data, and photographs illustrate on-the-job uses. Richmond Screw Anchor Co., 816-838 Liberty Ave., Brooklyn, N. Y.

film on shoring 839

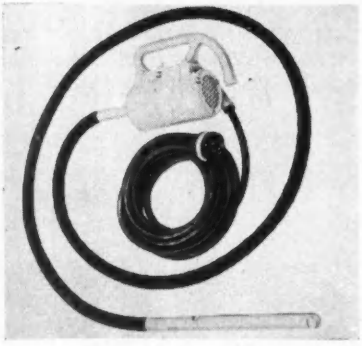
A 16-mm sound-color film available for loan to any contractor tells the complete story of modern heavy duty steel shoring in its application both to commercial slab and highway bridge construction. Laurence Myers Scaffolding Co., 61 Bluxome St., San Francisco, Calif.

industrial tractors 840

A folder pictures and describes a line of tractor-shovels, power-angling dozers, power-tilting bulldozers, wheel loaders, fork lifts and interchangeable attachments, all applicable for the contractor. J. I. Case Co., Racine, Wisc.

building project reports 841

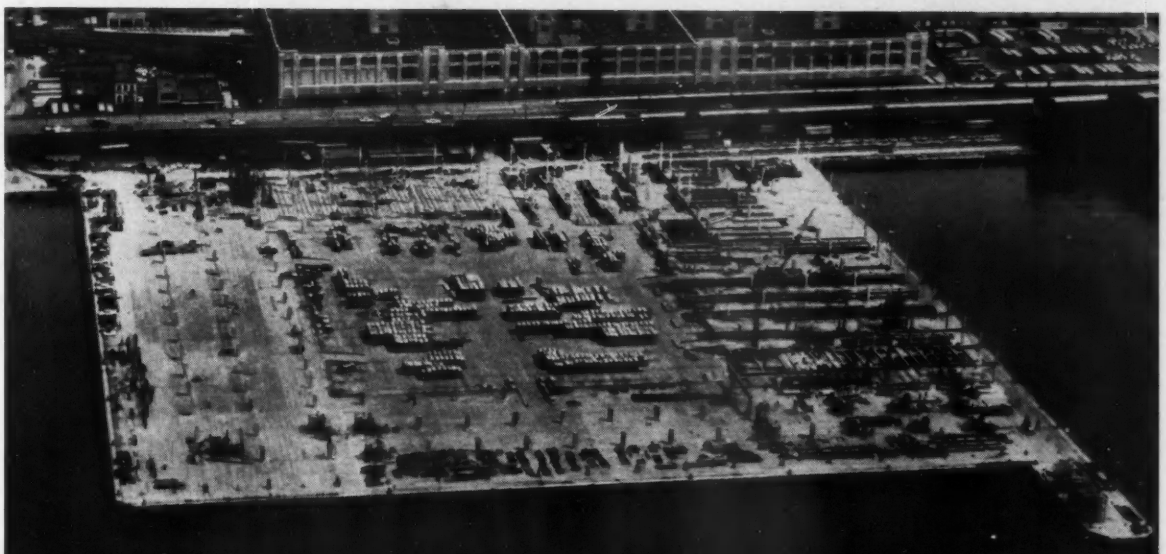
A 24-page booklet, "Dodge Reports: How to Use Them Effectively," explains fully the purpose and use of these construction reports. Dodge Reports tell you what new construction is contemplated, being planned, ready for bidding and what contracts have been awarded, as well as who will award the contract, specify materials and equipment, and do the buying. Suggestions on effective selling are included. F. W. Dodge Corp., Construction News Div., 119 W. 40th St., New York, N. Y.



vibrator 842

The homogenizing action of the high frequency, low amplitude vibration produced by a vibrator with a 1¼-inch diameter head results in concrete surfaces virtually free of pock marks, according to the manufacturer. Patching and finishing costs are claimed to be reduced to a minimum. The 120-volt 3-phase 180 cycle induction motor will not slow down and lose vibrating power in low slump concrete. Maginniss Power Tool Co., Mansfield, Ohio.

Controlled Concrete with
SONOTARD
for New York's Largest Pier now under construction



Holland-American Line, New York City
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Capt. Lewis H. Rabbage, Chief Engineer

Roberts & Schaefer Co.—Engineers
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The substructure of new Pier No. 40 is comprised of 6000 prestressed deck slabs uniquely placed upon a monolithically poured-in-place beam and cap system. The floor area is over 700,000 sq. ft.

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• A high degree of workability to facilitate placement has been maintained through high summer heat and a winter which recorded a low mark for sustained cold weather.

• The quantities of **SONOTARD** used were varied according to temperature to keep the water content and rate of hardening constant. At all temperatures **SONOTARD** produced a uniformly high strength with maximum density and eliminated shrinkage and cracking.

• **SONOTARD** played an essential role in the prestressed deck slabs and beams by controlling the initial rate of hardening and fluidity of concrete for optimum placement properties.

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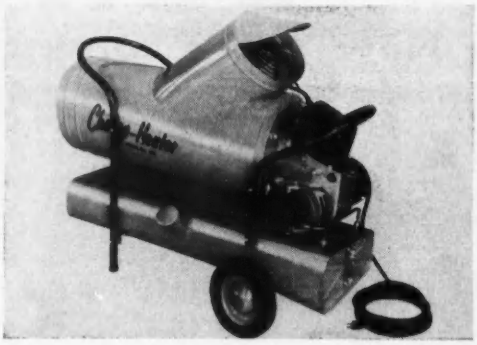

portable space heater **843**

Space heater has two entirely separate sources of air, one to support combustion and the other for heated air circulation. Thermostat turns unit off at a predetermined temperature and serves as a safety switch that prevents overheating. Heater operates on regular 110-115 volt, 60 cycle AC, and uses kerosene or number 1 fuel oil. Available in three sizes. Champion Heater Co., 3700 Forest Park, St. Louis, Mo.

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